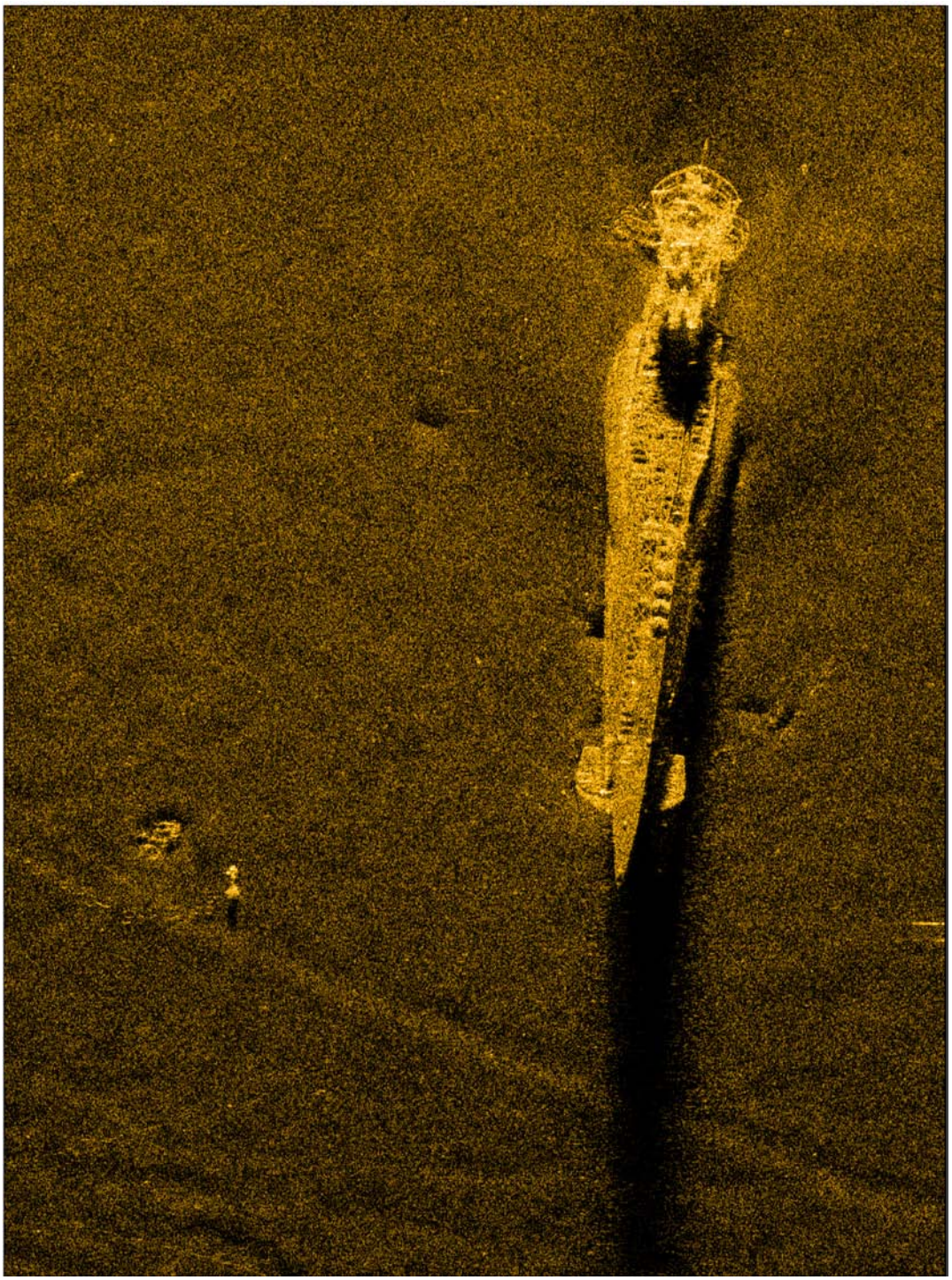
HISAS 1030

KONGSBERG

A very high resolution interferometric synthetic aperture sonar



(304311/ Rev.A / July 2006)

Basic concepts

The azimuth (along-track) resolution of a sonar can be computed as the ratio between the acoustic wavelength and the length of the array. For typical side scan sonars, this ratio is of the order 1:60-1:400 (meaning a resolution of 1 m at 60 and 400 m range, respectively). A longer array will increase this ratio, but fitting such a long array is not always possible or practical on most underwater vehicles. Operation at a higher frequency will increase the ratio, but will at the same time limit the achievable range due to higher absorption.

The Synthetic Aperture Sonar principle overcomes these limitations by utilising data from several consecutive pings to synthesise a longer sonar array. A fundamental limitation of SAS systems is that the platform cannot travel further than half the length of the receive array per ping interval (which in turn determines the range). For SAS systems, the maximum range is proportional to the receive array length, and inversely proportional to the platform speed.

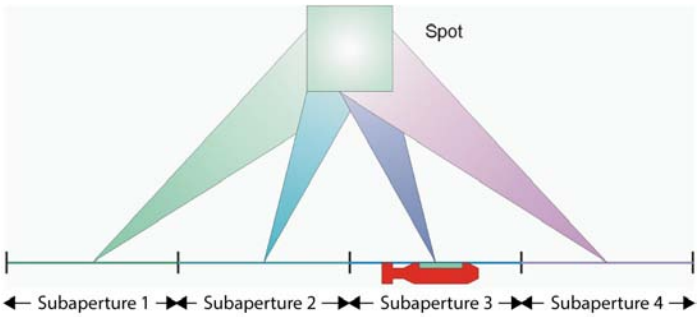
The theoretical azimuth resolution in SAS is half the length of each element in the receive array, at all ranges. In general, this resolution is not practically achievable, and the practical resolution will be 1.5 – 2 times lower. The range resolution is, as in regular side scan sonars, a function of the bandwidth.

Reverberation suppression

The multi-element transmit array and the programmable transmit waveform generator allows both beam direction and beam coverage to be varied to reduce influence of seabed and sea surface reverberation. Waveform, pulse length and transmit power are fully programmable.

Multi-aspect imaging

The small (in wavelengths) element size gives this sensor a wide field of view, facilitating the use of multi-aspect imaging. The principle is illustrated in the figure at the top of the page. In practice, the operator can view a continuous “movie” of an object seen from different aspect angles. This feature effectively adds another dimension to the data set, and greatly increases the probability of both manual and computerized classification of mine-like objects in cluttered areas.



Bathymetry

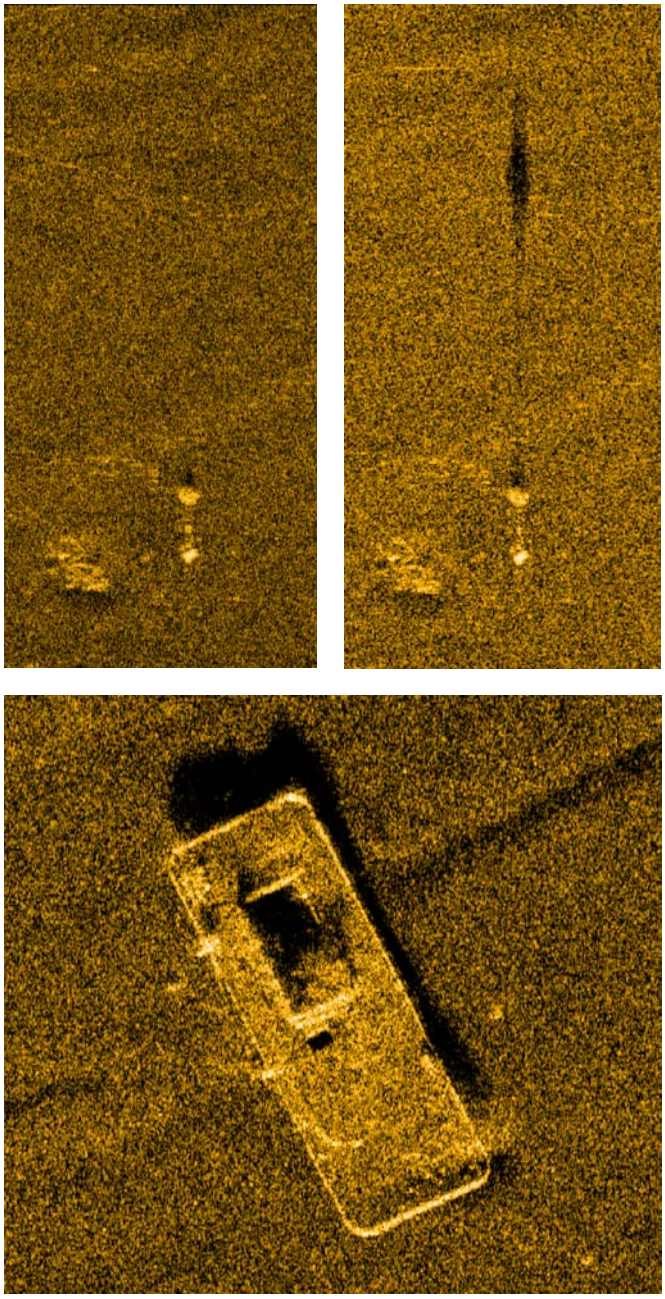
HISAS 1030 has two full-length receive arrays on each side of the AUV. They are used to form two SAS images of the same scene with slightly different geometry. This adds considerable robustness to the system, but it also allows very high resolution interferometric processing from SAS data. The specification is for relative bathymetry resolution better than 50x50 cm to full range, but in practice the resolution may be considerably better which will allow 3D imaging of mines and mine-like objects.

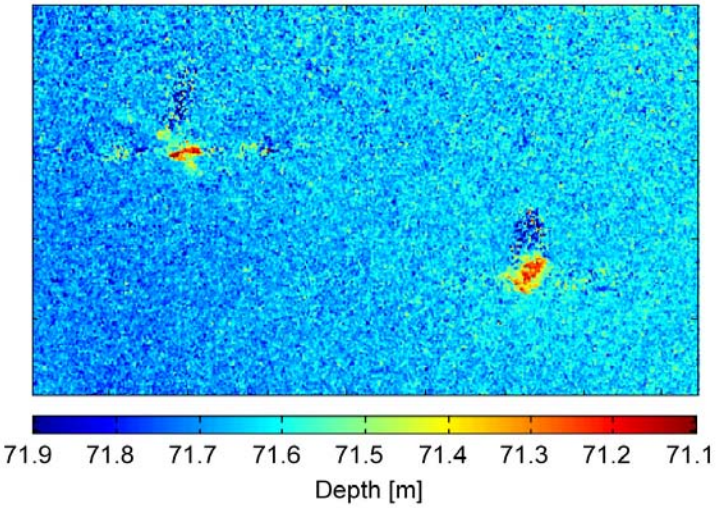
High resolution velocity measurement

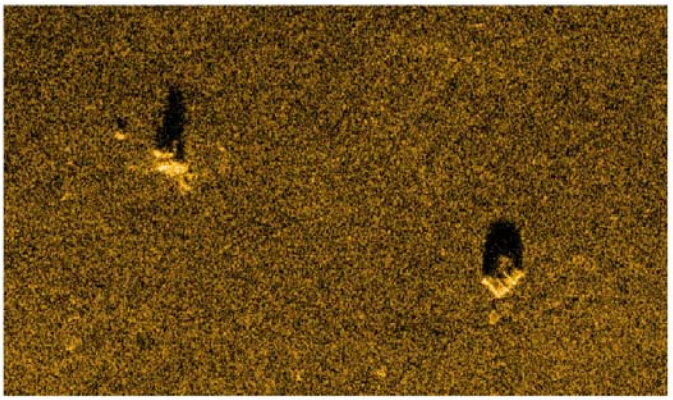
HISAS can optionally provide a highly accurate measurement of an AUV’s displacement (or velocity) in all three dimensions. This measurement can be utilised by an aided inertial navigation system, and will significantly reduce position error growth when absolute position dependent measurements are not available.

The front page illustration shows a HISAS 1030 image of the world war II Type VIIc submarine U-735, which was sunken in the Oslo fjord in 1944. The illustration is a detail view of the submarine centered at 65 m range.

Details like the railing on the submarines aft tower are clearly visible. Part of the hull is buried in the mud. The total length of the visible part of the submarine is 30 m.
The HUGIN AUV depth is 175 m, altitude 20 m.







The upper left images show the same set of data processed in two different ways. The objects imaged are a transponder floating above the seafloor attached with a rope to a sandbag. To the left a standard SAS image, to the right the result when the processing is set to emphasise the shadow of the transponder.

The lower left image shows a SAS image of a barge of size 10 x 3 m. The small rectangular hole, which measures about 30 x 40 cm, is at 60 m range.

SAS bathymetry (top) and SAS intensity (bottom) images of a rock and an oil drum. The range in the image is from 46 to 56 m.

FOCUS Synthetic Aperture Sonar Signal Processing Toolbox

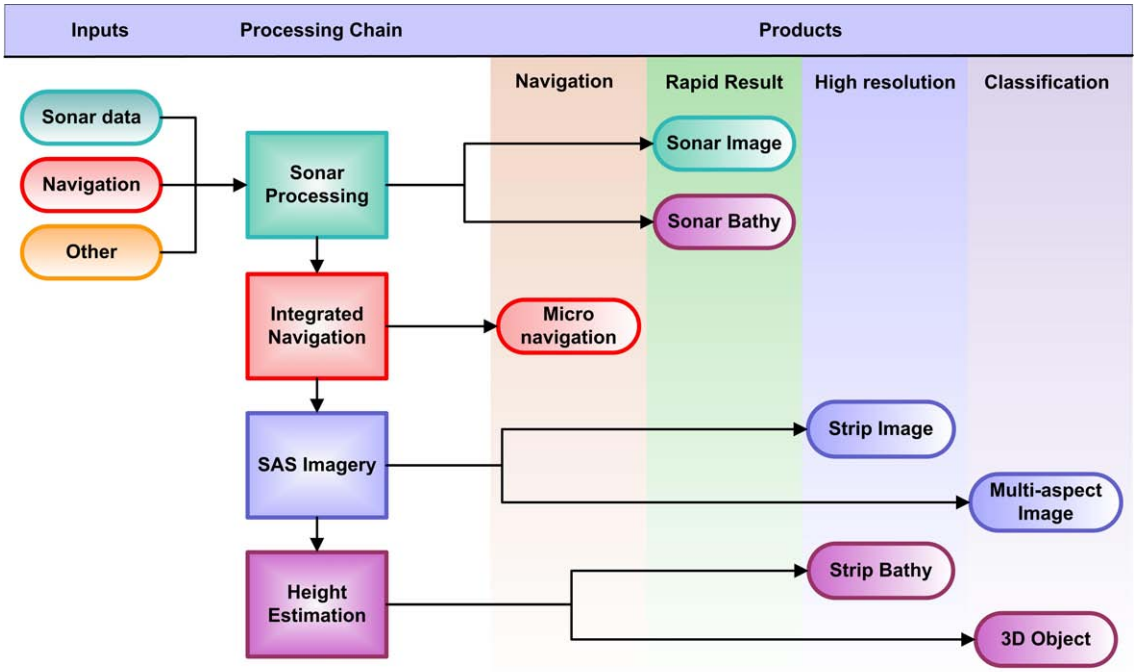
FOCUS is a complete SAS post-processing toolbox, delivered with HISAS 1030. The figure on the last page shows the main building blocks in FOCUS. The output products can be divided into four categories:

- Navigation
- Rapid result - dynamically focused multibeam side scan images, low resolution bathymetry
- High resolution - streaming SAS imagery and relative bathymetry of configurable resolution
- Classification - very high reolution imagery, bathymetry and other advanced products.

The toolbox includes integrated SAS micronavigation and inertial navigation, time and wavenumber domain beamforming, phase gradient autofocus (PGA) and seafloor height estimation by cross-correlation and interferometry. Data is made available in standard file formats (XTF sonar files, Kongsberg .ALL bathymetry data, GeoTIFF mosaic, etc).

Depending on the required processing speed, a range of hardware options are available. Typical processing speed is 2-5 times faster than real-time for high resolution SAS imagery. Solutions are available for intergrating FOCUS with third party post-mission analysis and display sofware.

Parts or all of the FOCUS processing can also be applied in real time inside the underwater vehicle at the expense of added volume, weight and power consumption.



The main building blocks of the FOCUS Synthetic Aperture Sonar Signal Processing Toolbox

Technical specifications

Main specifications

Frequencies .....60 - 120 kHz
System bandwidth.....Up to 50 kHz
On each side of the AUV:
Transmitter array, 0.35 m long/0.18 high
Primary receiver array, 1.27 m long/0.11 m high
Secondary recv. array, 1.27 m long/0.11 m high
Data rate: Up to 90GB/hour, typically 60 GB /hour

Removable RAID system in separate pressure container, providing 1.2 TB storage space for data recording.

Interface to HUGIN control system
HISAS Topside Payload Operator System
FOCUS post-processing system

Operational performance

Maximum range (operation geometry dependent).....	200 m @ 2 m/s speed / 275 @ 1.5 m/s speed
Maximum instantaneous area coverage rate (operation geometry dependent)	750 m²/s
Theoretical resolution (across-track x alongtrack)	2 x 2 cm
Practical resolution.....	< 5 x 5 cm
Multi-aspect field of view	Up to 30º
Bathymetry resolution (cell size)	5 x 5 cm to 50 x 50 cm

Kongsberg Maritime is engaged in continuous development of its products, and reserves the right to alter the specifications without further notice.

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